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SURVIVABILITY OF OVERWINTERING *ARGIOPE AURANTIA* (ARANEIDAE) EGG CASES, WITH AN ANNOTATED LIST OF ASSOCIATED ARTHROPODS

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ABSTRACT. Overwintering egg cases of the black and yellow garden spider, *Argiope aurantia* Lucas (Araneae: Araneidae), were observed during the late winter and early spring of 1985, 1986, and 1987 in Washington County, Mississippi. Of 120 egg cases monitored in the field in 1985, only three remained undamaged by the period of peak spiderling emergence in May. An additional 115 field-collected egg cases were observed in the laboratory in 1985. A total of 23,840 *A. aurantia* spiderlings emerged from the lab egg cases (mean = 341), with 1212 spiderlings emerging from one undamaged egg case. Adults or pupae of either the parasitic ichneumonid wasp, *Tromatopia rufopectus* (Cr.), or the parasitic chloropid fly, *Pseudogaurax signatus* (Loew), emerged from 56% of the field-collected egg cases. Nineteen species of insects, representing 19 genera, 15 families and 5 orders were collected from lab-reared egg cases in 1985. In addition, 11 species of spiders were recovered from *A. aurantia* egg cases. In 1985, 97% of the egg cases observed in the field showed evidence of bird damage. In both 1986 and 1987, 100% of the egg cases were damaged by birds.

The black and yellow garden spider, *Argiope aurantia* Lucas, is a common orb-weaving spider found throughout the eastern part of the United States and along the west coast of North America into Central America (Levi 1968). It has been reported from a variety of habitats, including dense perennial vegetation, dry grassy hillsides, vegetable gardens, roadside and deciduous woods margins, and areas adjacent to streams, ponds, and swamps (Gertsch 1979). Observations on the general life habits, systematics, and distribution of *A. aurantia* and related species were summarized by Levi (1968). Other workers have reported on the biology of this species, including overwintering behavior and ecology (Enders 1974, 1977; Riddle & Markezich 1981; Howell & Ellender 1984; Heiber 1985). Minimal information is available, however, concerning the nature and degree of overwintering mortality. Adults and juveniles of *A. aurantia* do not typically survive the winter, even in the southern United States. Adult females of this species produce egg cases containing many hundreds of eggs in late summer and fall. The eggs hatch during winter and the spiderlings remain in the egg case until spring (Tolbert 1976). The present study examines the overwintering survivability of *A. aurantia* egg cases in old fields and roadside margins of Washington County, Mississippi.

METHODS

In January of 1985, nine sites were selected within the Delta Experimental Forest (DEF) located 3.0 km north of Stoneville, Washington County, Mississippi. Four of the sites (Sites 1, 6, 8 and 9) were roadside margins that averaged 1.0–2.0 m in width and had varied plant communities. Sites 2, 3, 4, 5, and 7 were old field successional habitats that ranged from a relatively small field (10 × 100 m, site 4) to an area 2.0 km long and 100 m wide (site 7). Mixed tall forbs (e.g., *Solidago* sp. and *Aster pilosus*) predominated. All sites were within an area (3.5 km × 1.0 km) of the DEF bounded on three sides by soybean, cotton, or fallow fields.

At each site, egg cases of *A. aurantia* were detected by walking parallel linear routes and visually searching the vegetation. Each egg-case location was marked by a 0.5 m strip of red and white flagging tape, with a unique alpha-numeric code written on the tape in indelible ink. To minimize attraction of birds to the colored tape and its associated egg case, the tape was attached

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to vegetation 0.5–1.0 m distant from the egg case. Data were recorded for each egg case and included condition, height above ground, vegetation substrate, degree of exposure, and number of adjacent egg cases within 2.0 m. Marked egg cases were monitored at 30-day intervals in February and March and at 15-day intervals in April and May. At each monitoring, the condition and possible mortality cause(s) were determined. Tolbert (1976) concluded that damage exceeding 10% of the surface area or subsequent disappearance of the *Argiope* egg case was attributable to bird predation. The same criterion was used in our field evaluations. There is no indication, from a search of the literature or from our own observations, that mammal predation is a significant mortality factor in this type of situation. Damage that involved less than 10% of the egg case surface was attributed to insects. This category also was designated when insect emergence holes were detected.

In January 1985, 235 egg cases of *A. aurantia* were located; 120 were marked for future field observations and 115 were removed for laboratory observation. Each collected egg case was placed in a plastic 8 oz.(235 ml) cup with an organdy screen cover held in place by lids from which a 5.0 cm diameter circle had been removed. Cups were then placed outside the laboratory in a screened enclosure with a rain cover. These conditions approximated the temperature and humidity regimens experienced by egg cases that remained in the field. In January 1986 and 1987, field surveys for egg cases were conducted at the same sites as in 1985; however, egg cases were not collected.

RESULTS

Field Observations:—Eighteen percent of the 120 egg cases marked in January 1985 showed previous damage, apparently caused by birds. By mid-February, the percent of damage caused by birds to these egg cases had increased to 64%. In late May, 97% of the egg cases either had been extensively damaged by birds or had disappeared altogether. The remaining 3% of field egg cases in 1985 showed evidence of either insect parasitization or predation.

On one occasion in 1985, we observed actual bird damage to an egg case. During the morning of 19 February, a male House Sparrow, *Passer domesticus domesticus*, was seen removing the contents of a previously undamaged egg case. The bird was startled by our approach and took flight with the eviscerated egg case clasped in its beak and strings of material trailing behind as it disappeared from view.

In mid-January 1986, 27% of the 143 detected egg cases showed evidence of bird damage. In mid-January 1987, all of the 13 detected egg cases showed evidence of bird damage. Over all sites, egg case density also declined during the three survey years. In 1985, density averaged > 5 egg cases per 30 square m. In 1986, this had decreased to slightly > 1.0 egg case per 30 sq. m. In 1987, only 13 egg cases were located within all 9 sites and averaged < 0.1 egg case per 30 sq. m.

Laboratory Observations.—*A. aurantia* spiderlings emerged from all but one of 115 egg cases retained in enclosures from January to June of 1985. Total emerged spiderlings from egg cases (n = 114) was 23,840; range per egg case: 1 (extensively damaged egg case) to 1212 (completely undamaged egg case). The mean emergence from the 114 egg cases was 341 (±81 SE) spiderlings. Thirty-five of the 115 field-collected egg cases were initially damaged by birds. Eventual emergence of spiderlings from these egg cases ($\bar{x}$ = 55 ±17 SE) was considerably less than from insect-damaged egg cases ($\bar{x}$ = 134 ±32 SE) and from undamaged egg cases ($\bar{x}$ = 456 ±148 SE).

During enclosure observations, more than 4700 non-host arthropods also emerged from the 115 egg cases (Table 1). Two species of wasps (Hymenoptera) comprised 83.7% of all emerging non-host arthropods, and one species of fly (Diptera) comprised an additional 14.5%. These three species were: the ichneumonid wasp, *Tromatobia rufopectus* (Say), the eulophid wasp, *Pediobius brachycerus* (Thomson), and the chloropid fly, *Pseudogaurax signatus* (Loew).

Thirty-eight (33%) of the 115 egg cases reared in enclosures were parasitized by *T. rufopectus* ($\bar{x}$ = 6.8 ±1.9 SE *T. rufopectus* pupae per egg case). Only one adult of this species emerged, however, because 258 of the 259 *T. rufopectus* pupae were parasitized by *P. brachycerus*. This hyperparasite produced more than 3700 individuals from the 258 host pupae ($\bar{x}$ = 14.4 ±5.1 SE per pupa). Seven additional species of Hymenoptera also were found in the examined egg cases (Table 1). Of these, only the eupelmid, *Arachnophaga scutata* Gahan, and the eulophid, *Tetrastichus* sp., are known parasites of spider eggs (Eason et al. 1967).

The chloropid fly, *P. signatus*, is an obligate

Table 1.—Arthropods associated with 115 egg cases of *Argiope aurantia* in 1985 in Washington County, Mississippi. * Less than 1%.

Taxon	Percent occurrence in egg sacs	Number of individuals
Psocoptera	*	1
Coleoptera		
Carabidae		
Calleida decora Fab.	*	1
Stenolophus dissimilis DeJ.	*	1
Hydrophilidae		
Cercyon sp.	2	2
Lathridiidae		
Corticaria sp.	3	3
Mycetophagidae		
Litargus sp.	*	1
Rhyncophoridae		
Lixus concavus Say	*	1
Diptera		
Chloropidae		
Pseudogaurax signatus (Loew)	43	687
Lepidoptera		
Arctiidae		
Lithosiinae	2	2
Noctuidae		
Palthis asopialis Guenee	*	1
Hymenoptera		
Braconidae		
Agathis sp.	*	1
Eulophidae		
Pediobius brachycerus (Thomson)	30	3713
Pnigalio sp.	*	1
Tetrastichus sp.	*	1
Eupelmidae		
Arachnophaga scutata Gahan	*	1
Formicidae		
Tapinoma sessile (Say)	*	20
Ichneumonidae		
Itoplectus conquistor (Say)	2	2
Tromatobia rufopectus Cr.	33	259
Pteromalidae		
Pteromalus sp.	*	1
Araneae		
Araneidae		
Eustala cepina (Walck)	*	1
Dictynidae		
Dictyna sp.	*	1
Dictyna hentzi Kaston	2	2
Philodromidae		
Philodromus sp.	*	1
Salticidae		
Eris marginata (Walck)	*	1
Hentzia sp.	2	2
Maevia sp.	*	1
Metaphidippus sp.	5	6
Metaphidippus galathea (Walck)	4	4
Phidippus audax Hentz	*	1
Phidippus clarus Keys	6	27
Tutelina sp.	*	1
	Total	4746

predator of spider eggs (Heiber 1984). In 1985, 43% of the enclosure egg cases produced adult *P. signatus* flies. However, only 26 egg cases were attacked singly by this fly; an additional 23 egg cases were attacked by both *P. signatus* and *T. rufopectus*.

Other workers have indicated possible predation of *A. aurantia* eggs by lepidopterous larvae (Heiber 1984, Austin 1985). In our study, two arctiid larvae (subfamily Lithosiinae) were found within the confines of damaged egg cases (Table 1). This subfamily is known to feed only on lichens (Holland 1968). One noctuid moth, *Palthis asopialis* Guenee, emerged from an extensively damaged egg case. Its pupal case and numerous fecal pellets were recovered from within the egg case, suggesting that spider eggs or egg case material had served as food for the larva. Six species of Coleoptera were found in association with *A. aurantia* egg cases. Only one, the carabid beetle *Calleida decora* Fab., is a known predator; however, it was not observed feeding on spider eggs or spiderlings.

Eleven species of spiders, representing nine genera and four families, were obtained from field-collected *A. aurantia* egg cases in the laboratory. These spiders probably were secondary invaders that entered holes made by insects or birds. In one instance, an egg case and dead female of the salticid, *Phidippus clarus* Keyserling, were found in a damaged *A. aurantia* egg case. Subsequently, 20 *P. clarus* spiderlings emerged on 2 April, followed on 3 May by 412 *A. aurantia* spiderlings. Other spiders have been observed feeding on *A. aurantia* spiderlings in the egg case (Tolbert 1976). We, however, observed no such interspecific predation by spiders.

DISCUSSION

Sources of mortality to overwintering spider eggs can be partitioned into abiotic and biotic parameters. In the southeastern United States, abiotic factors (e.g., weather) are considered of minor importance to winter survival of *A. aurantia* spiderlings inside egg cases (Tolbert 1979; Riddle 1980). Biotic factors (e.g., predation and parasitization) are postulated to have a more profound affect on survival (Auten 1925; Eason et al. 1967).

Birds have been recorded as a major group of predators of orb-weaving spiders on their webs (Marples 1969; Robinson & Robinson 1970; Blanke 1972; Waide & Hailman 1977), including *A. aurantia* (Horton 1983). Birds have also been implicated as a major source of mortality for overwintering arboreal spiders (Gunnarson 1983). Bird predation on spider egg cases and their contents, however, has been mostly documented by anecdotal or circumstantial evidence. Several studies estimated rates of bird predation on orb-weaving spider egg cases that ranged from 7–42% (Enders 1974; Tolbert 1976; Heiber 1984). These studies, however, were conducted only in the fall of each observation year; continued observations into the spring probably would have produced higher incidences of bird predation, perhaps approximating the 100% values observed during our study. During the January to May period of our investigation, birds were foraging both for food and for nesting materials. The local bird density was also increasing during this period, as summer residents were returning and migrants were passing through on the way north. These factors suggest that the level of bird predation on egg cases that we observed may be both typical for such situations and comparable with the results of other investigations.

Egg cases of *A. aurantia* that are damaged by birds provide nesting sites and sheltered habitats for many arthropod species, including other spiders. Many of these associated species are predators or scavengers and may consume host spider eggs or spiderlings. Conversely, they also may consume other predators or parasites of spiders and consequently reduce the overall impact of such organisms on *A. aurantia* eggs and spiderlings. Our data does not allow a determination of the net effect of predator/scavenger arthropods associated with egg cases on the population dynamics of *A. aurantia*.

The level of egg-case parasitization demonstated by *T. rufopectus* in 1985—33%—is in general agreement with values found in previous studies (e.g., 21.5%, Enders 1974; 26.3%, Tolbert 1976; 36.1%, Heiber 1984). *T. rufopectus* is a well known parasitoid of spider eggs and was first described by Cresson (1870) from *A. aurantia* egg cases. It attacks *A. aurantia* eggs by inserting its long ovipositor through the outer cover of the egg case into the flocculent layer. Wasp eggs are deposited on or near the host egg mass and the emerging wasp larvae make their way to the host eggs and burrow into the mass to feed. *P. brachycerus*, a parasitoid of *T. rufopectus*, does no known damage to spider eggs or spiderlings (Peck 1985).

Previous studies have shown the chloropid fly, *P. signatus,* to be a fairly common parasitoid of *A. aurantia* eggs (Enders 1974; Tolbert 1976; Heiber 1984, 1985). However, parasitization values observed during our study were 3–4 times greater than those found previously (Tolbert 1976; Heiber 1984). *P. signatus* oviposits on egg case surfaces, whereupon after fly egg hatch the larvae force their way through the outer covering into the host egg mass (Kessel & Kessel 1937; Hickman 1970). Heiber (1984) found that the level of successful parasitization of *P. signatus* increased significantly when it attacked egg cases already damaged by other parasitoids or predators. These data suggest that prior egg case damage may be an important factor in successful parasitization by this chloropid fly.

The egg cases of *A. aurantia* are assumed to have evolved to protect their contents from one or more mortality factors. It is apparent from our study, however, that these structures have not prevented considerable mortality to their contents caused by bird damage or by parasitization. These two mortality factors, when added to subsequent mortality of spiderlings in the egg case caused by other agents, may be the major determinants of *A. aurantia* population density in old field and margin habitats. On the other hand, bird predation or parasitization typically does not cause complete mortality in affected egg cases. The number of survivors from such egg cases, combined with those from unaffected egg cases, may be sufficient to maintain population levels of *A. aurantia* in a particular area. Because of the large-scale removal of egg cases from our field sites for laboratory study, the subsequent decline in *A. aurantia* populations cannot be definitively ascribed to either natural or investigator-associated parameters. Determining the relative importance of various mortality factors associated with *A. aurantia* egg cases awaits further experimentation.

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